For information about job opportunities in companies other than airlines, consult the classified section of aviation trade magazines and apply to companies that operate aircraft at local airports.

Air Traffic Controllers

(O*NET 39002)

Significant Points

- Nearly all air traffic controllers are employed and trained by the Federal Government.
- Keen competition is expected in this occupation.
- Aircraft controllers earn relatively high pay and have good benefits.

Nature of the Work

The air traffic control system is a vast network of people and equipment that ensures the safe operation of commercial and private aircraft. Air traffic controllers coordinate the movement of air traffic to make certain that planes stay a safe distance apart. Their immediate concern is safety, but controllers also must direct planes efficiently to minimize delays. Some regulate airport traffic; others regulate flights between airports.

Although *airport tower* or *terminal controllers* watch over all planes traveling through the airport's airspace, their main responsibility is to organize the flow of aircraft in and out of the airport. Relying on radar and visual observation, they closely monitor each plane to ensure a safe distance between all aircraft and to guide pilots between the hangar or ramp and the end of the airport's airspace. In addition, controllers keep pilots informed about changes in weather conditions such as wind shear—a sudden change in the velocity or direction of the wind that can cause the pilot to lose control of the aircraft.

During arrival or departure, several controllers direct each plane. As a plane approaches an airport, the pilot radios ahead to inform the terminal of its presence. The controller in the radar room, just beneath the control tower, has a copy of the plane's flight plan and already has observed the plane on radar. If the path is clear, the controller directs the pilot to a runway; if the airport is busy, the plane is fitted into a traffic pattern with other aircraft waiting to land. As the plane nears the runway, the pilot is asked to contact the tower. There, another controller, who also is watching the plane on radar, monitors the aircraft the last mile or so to the runway, delaying any departures that would interfere with the plane's landing. Once the plane has landed, a ground controller in the tower directs it along the taxiways to its assigned gate. The ground controller usually works entirely by sight, but may use radar if visibility is very poor.

The procedure is reversed for departures. The ground controller directs the plane to the proper runway. The local controller then informs the pilot about conditions at the airport, such as weather, speed and direction of wind, and visibility. The local controller also issues runway clearance for the pilot to take off. Once in the air, the plane is guided out of the airport's airspace by the departure controller.

After each plane departs, airport tower controllers notify *enroute controllers* who will next take charge. There are 21 enroute control centers located around the country, each employing 300 to 700 controllers, with more than 150 on duty during peak hours at the busier facilities. Airplanes usually fly along designated routes; each center is assigned a certain airspace containing many different routes. Enroute controllers work in teams of up to three members, depending on how heavy traffic is; each team is responsible for a section of the center's airspace. A team, for example, might be responsible for all planes that are between 30 to 100 miles north of an airport and flying at an altitude between 6,000 and 18,000 feet.

To prepare for planes about to enter the team's airspace, the radar associate controller organizes flight plans coming off a printer. If two planes are scheduled to enter the team's airspace at nearly the same time, location, and altitude, this controller may arrange with the preceding control unit for one plane to change its flight path. The previous unit may have been another team at the same or an adjacent center, or a departure controller at a neighboring terminal. As a plane approaches a team's airspace, the radar controller accepts responsibility for the plane from the previous controlling unit. The controller also delegates responsibility for the plane to the next controlling unit when the plane leaves the team's airspace.

The radar controller, who is the senior team member, observes the planes in the team's airspace on radar and communicates with the pilots when necessary. Radar controllers warn pilots about nearby planes, bad weather conditions, and other potential hazards. Two planes on a collision course will be directed around each other. If a pilot wants to change altitude in search of better flying conditions, the controller will check to determine that no other planes will be along the proposed path. As the flight progresses, the team responsible for the aircraft notifies the next team in charge. Through team coordination, the plane arrives safely at its destination.

Both airport tower and enroute controllers usually control several planes at a time; often, they have to make quick decisions about completely different activities. For example, a controller might direct a plane on its landing approach and at the same time provide pilots entering the airport's airspace with information about conditions at the airport. While instructing these pilots, the controller also would observe other planes in the vicinity, such as those in a holding pattern waiting for permission to land, to ensure that they remain well separated.

In addition to airport towers and enroute centers, air traffic controllers also work in flight service stations operated at over 100 locations. These *flight service specialists* provide pilots with information on the station's particular area, including terrain, preflight and inflight weather information, suggested routes, and other information important to the safety of a flight. Flight service station specialists help pilots in emergency situations and initiate and coordinate searches for missing or overdue aircraft. However, they are not involved in actively managing air traffic.

Some air traffic controllers work at the Federal Aviation Administration's (FAA) Air Traffic Control Systems Command Center in Herndon, Virginia, where they oversee the entire system. They look for situations that will create bottlenecks or other problems in the system, then respond with a management plan for traffic into and out of the troubled sector. The objective is to keep traffic levels in the trouble spots manageable for the controllers working at enroute centers.

Currently, the FAA is in the midst of developing and implementing a new automated air traffic control system. As a result, more powerful computers will help controllers deal with the demands of increased air traffic. Some traditional air traffic controller tasks—like determining how far apart planes should be kept—will be done by computer. Present separation standards call for a 2,000-foot vertical spacing between two aircraft operating above 29,000 feet and flying the same ground track. With the aid of new technologies, the FAA will be able to reduce this vertical separation standard to 1,000 feet. Improved communication between computers on airplanes and those on the ground also is making the controller's job a little easier.

At present controllers sit at consoles with green-glowing screens that display radar images generated by a computer. In the future, controllers will work at a modern workstation computer that depicts air routes in full-color on a 20- by 20-inch screen. The controllers will select radio channels simply by touching on-screen

buttons instead of turning dials or switching switches. The new technology will also enable controllers to zoom in on selected corners of the air space that is their responsibility and get better images of moving traffic than is possible with today's machines. However, the new automated air traffic control system will not be fully operational until at least 2003.

The FAA is also considering implementing a system called "free flight" which would give pilots much more freedom in operating their aircraft. The change will require new concepts of shared responsibility between controllers and pilots. Air traffic controllers will still be central to the safe operation of the system, but their responsibilities will eventually shift from controlling to monitoring flights. At present, controllers assign routes, altitudes, and speeds. Under the new system, airlines and pilots would choose them. Controllers would intervene only to ensure that aircraft remained at safe distances from one another, to prevent congestion in terminal areas and entry into closed airspace, or to otherwise ensure safety. Today's practices often result in planes zigzagging from point to point along corridors rather than flying from city to city in a straight line. This results in lost time and fuel. However, it may be several years before a free flight system is implemented, despite its potential advantages. For the system to work, new equipment must be added for pilots and controllers, and new procedures developed to accommodate both the tightly controlled and flexible aspects of free flight. Budget constraints within the Federal Government may delay or slow implementation.

Working Conditions

Controllers work a basic 40-hour week; however, they may work additional hours for which they receive overtime pay or equal time off. Because most control towers and centers operate 24 hours a day, 7 days a week, controllers rotate night and weekend shifts.

During busy times, controllers must work rapidly and efficiently. This requires total concentration to keep track of several planes at the same time and make certain all pilots receive correct instructions. The mental stress of being responsible for the safety of several aircraft and their passengers can be exhausting for some persons.

Employment

Air traffic controllers held about 30,000 jobs in 1998. They were employed by the Federal Government at airports—in towers and flight service stations—and in enroute traffic control centers. The overwhelming majority worked for the FAA.. Some professional controllers conduct research at the FAA's national experimental center near Atlantic City, New Jersey. Others serve as instructors at the FAA Academy in Oklahoma City, Oklahoma. A small number of civilian controllers worked for the Department of Defense. In addition to controllers employed by the Federal Government, some worked for private air traffic control companies providing service to non-FAA towers.

Controllers are usually responsible for several planes at one time.

Training, Other Qualifications, and Advancement

Air traffic controller trainees are selected through the competitive Federal Civil Service system. Applicants must pass a written test that measures their ability to learn the controller's duties. Applicants with experience as a pilot, navigator, or military controller can improve their rating by scoring well on the occupational knowledge portion of the examination. Abstract reasoning and three-dimensional spatial visualization are among the aptitudes the exam measures. In addition, applicants usually must have 3 years of general work experience or 4 years of college, or a combination of both. Applicants also must survive a week of screening at the FAA Academy in Oklahoma City, which includes aptitude tests using computer simulators and physical and psychological examinations. Successful applicants receive drug screening tests. For airport tower and enroute center positions, applicants must be less than 31 years old. Those 31 years old and over are eligible for positions at flight service stations.

Controllers must be articulate, because pilots must be given directions quickly and clearly. Intelligence and a good memory also are important because controllers constantly receive information that they must immediately grasp, interpret, and remember. Decisiveness is also required because controllers often have to make quick decisions. The ability to concentrate is crucial because controllers must make these decisions in the midst of noise and other distractions.

Trainees learn their jobs through a combination of formal and on-the-job training. They receive 7 months of intensive training at the FAA academy, where they learn the fundamentals of the airway system, FAA regulations, controller equipment, aircraft performance characteristics, as well as more specialized tasks. To receive a job offer, trainees must successfully complete the training and pass a series of examinations, including a controller skills test that measures speed and accuracy in recognizing and correctly solving air traffic control problems. The test requires judgments on spatial relationships and requires application of the rules and procedures contained in the Air Traffic Control Handbook. Based on aptitude and test scores, trainees are selected to work at either an enroute center or a tower.

After graduation, it takes several years of progressively more responsible work experience, interspersed with considerable classroom instruction and independent study, to become a fully qualified controller. This training includes instruction in the operation of the new, more automated air traffic control system—including the automated Microwave Landing System that enables pilots to receive instructions over automated data links—that is being installed in control sites across the country.

Controllers who fail to complete either the academy or the on-the-job portion of the training are usually dismissed. Controllers must pass a physical examination each year and a job performance examination twice each year. Failure to become certified in any position at a facility within a specified time may also result in dismissal. Controllers also are subject to drug screening as a condition of continuing employment.

At airports, new controllers begin by supplying pilots with basic flight data and airport information. They then advance to ground controller, then local controller, departure controller, and finally, arrival controller. At an enroute traffic control center, new controllers first deliver printed flight plans to teams, gradually advancing to radar associate controller and then radar controller.

Controllers can transfer to jobs at different locations or advance to supervisory positions, including management or staff jobs in air traffic control and top administrative jobs in the FAA. However,

there are only limited opportunities for a controller to switch from a position in an enroute center to a tower.

Job Outlook

Extremely keen competition is expected for air traffic controller jobs because the occupation attracts many more qualified applicants than the small number of job openings that result from replacement needs. Turnover is very low because of the relatively high pay and liberal retirement benefits, and controllers have a very strong attachment to the occupation. Most of the current work force was hired as a result of the controller's strike during the 1980's, so the average age of current controllers is fairly young. Relatively few controllers will be eligible to retire over the 1998-2008 period.

Employment of air traffic controllers is expected to show little or no change through the year 2008. Employment growth is not expected to keep pace with growth in the number of aircraft flying because of the implementation of a new air traffic control system over the next 10 years. This computerized system will assist the controller by automatically making many of the routine decisions. Automation will allow controllers to handle more traffic, thus increasing their productivity.

Air traffic controllers who continue to meet the proficiency and medical requirements enjoy more job security than most workers. The demand for air travel and the workloads of air traffic controllers decline during recessions, but controllers seldom are laid off.

Earnings

Median annual earnings of air traffic controllers in 1998 were $64,880. The middle 50 percent earned between $50,980 and $78,840. The lowest 10 percent earned less than $36,640 and the highest 10 percent earned more than $87,210.

The average annual salary for air traffic controllers in the Federal Government—which employs 86 percent of the total—in nonsupervisory, supervisory, and managerial positions was $48,300 in 1999. Both the worker's job responsibilities and the complexity of the particular facility determine a controller's pay. For example, controllers who work at the FAA's busiest air traffic control facilities earn higher pay.

Depending on length of service, air traffic controllers receive 13 to 26 days of paid vacation and 13 days of paid sick leave each year, life insurance, and health benefits. In addition, controllers can retire at an earlier age and with fewer years of service than other Federal employees. Air traffic controllers are eligible to retire at age 50 with 20 years of service as an active air traffic controller or after 25 years of active service at any age. There is a mandatory retirement age of 56 for controllers who manage air traffic.

Related Occupations

Other occupations that involve the direction and control of traffic in air transportation are airline-radio operator and airplane dispatcher.

Sources of Additional Information

Information on acquiring a job as an air traffic controller with the Federal Government may be obtained from the Office of Personnel Management (OPM) through a telephone-based system. Consult your telephone directory under U.S. Government for a local number or call (912) 757-3000; TDD (912) 744-2299. That number is not toll free and charges may result. Information also is available from their Internet site: **http://www.usajobs.opm.gov**

Engineers

Significant Points

- A bachelor's degree is required for entry-level jobs.
- Starting salaries are significantly higher than those of college graduates in other fields.
- Continuing education is critical to keep abreast of the latest technology.

Nature of the Work

Engineers apply the theories and principles of science and mathematics to research and develop economical solutions to technical problems. Their work is the link between scientific discoveries and commercial applications. Engineers design products, machinery to build those products, factories in which those products are made, and the systems that ensure the quality of the product and efficiency of the workforce and manufacturing process. Engineers design, plan, and supervise the construction of buildings, highways, and transit systems. They develop and implement improved ways to extract, process, and use raw materials, such as petroleum and natural gas. They develop new materials that both improve the performance of products and help implement advances in technology. They harness the power of the sun, the Earth, atoms, and electricity for use in supplying the Nation's power needs, and create millions of products using power. Engineering knowledge is applied to improving many things, including the quality of health care, the safety of food products, and the efficient operation of financial systems.

Engineers consider many factors when developing a new product. For example, in developing an industrial robot, engineers determine precisely what function the robot needs to perform; design and test the robot's components; fit the components together in an integrated plan; and evaluate the design's overall effectiveness, cost, reliability, and safety. This process applies to many different products, such as chemicals, computers, gas turbines, helicopters, and toys.

In addition to design and development, many engineers work in testing, production, or maintenance. These engineers supervise production in factories, determine the causes of breakdowns, and test manufactured products to maintain quality. They also estimate the time and cost to complete projects. Some work in engineering management or in sales, where an engineering background enables them to discuss technical aspects and assist in product planning, installation, and use. (See the statements on engineering, natural science, and computer and information systems managers, and manufacturers' and wholesale sales representatives, elsewhere in the *Handbook*.)

Most engineers specialize. More than 25 major specialties are recognized by professional societies, and the major branches have numerous subdivisions. Some examples include structural, environmental, and transportation engineering, which are subdivisions of civil engineering; and ceramic, metallurgical, and polymer engineering, which are subdivisions of materials engineering. Engineers may also specialize in one industry such as motor vehicles or in one field of technology, such as jet engines or semiconductor materials.

This section, which contains an overall discussion of engineering, is followed by separate sections on 10 engineering branches: Aerospace, chemical, civil, electrical and electronics, industrial, materials, mechanical, mining, nuclear, and petroleum engineering. (Computer engineers are discussed in the statement on computer systems analysts, engineers, and scientists elsewhere in the *Handbook*.) Some branches of engineering not covered in detail here, but for which there are established college programs, include architectural engineering—the design of a building's internal support structure; biomedical engineering—the application of engineering